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TOO CHEAP TO EAT:
THE SIGNALING EFFECT OF PRICE ON FOOD SAFETY

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ABSTRACT

We investigate the effects on consumer's utility of price and remaining days until sell-by date of food, using a conjoint analysis. Examples of the food products we consider in our analysis are eggs, noodles, and cookies. We find that consumers prefer foods that have a longer shelf-life. Furthermore, the result of our analysis on eggs shows that consumer's utility increases with price, when the price exceeds a critical level. This is because consumers may perceive a correlation between a higher price and safer foods.

Keywords: food safety, sell-by date, conjoint analysis

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1. Introduction

In Japan, food wastage is a serious problem.[1] In FY 2006 alone, food wastage amounted to about 90 kg per capita. A possible resolution to this issue would be to permit retailers to sell unsold food at a bargain price. However, if the bargain price is too low, there is a possibility that the consumer might consider the food to be unsafe for consumption. Hence, the bargain strategy is not always successful. This is because the level of price affects the consumer's prediction of product quality. That is, when the price of a product is high, the consumer might presume that the product has high quality. On the other hand, when the price is low, the consumer might presume that the quality is low. We call the price's sign for product quality the signaling effect. Hence, when there is a signaling effect on food prices, it is important to understand the impact of this effect in order to develop an economically sound policy for the reduction of food wastage.

Through a conjoint analysis, this paper examines the consumer's willingness to pay for products with more days remaining before their sell-by date, considering three types of food products: eggs, noodles, and cookies. In particular, we consider the following questions: (1) In order to sell foods with fewer days remaining until sell-by date, how much discount should retailers offer? (2) Is there a possibility that consumers would not want to buy the product if it is sold cheaply? The empirical result of this paper shows that a signaling effect was found in the case of eggs, but not in the case of noodles and cookies.

There are some studies that consider the relationships between the price and quality of goods from theoretical perspectives. Pollak (1977) shows that even if the prices of some products are the same at some point of time, an individual may recognize them to have different price histories and may evaluate each product as a different commodity. Wolinsky (1983) considers a model of asymmetric information, where a firm is aware of the quality of the goods, but the consumers are not. He shows that the consumer can determine the product's quality through its equilibrium with respect to price. Jones and Hudson (1996) show that price can transmit information or signal on the quality of the goods. That is, when the price of a product is high, the individual tends to think that the product's quality is also high.

Empirical studies relating to the topic include conjoint analysis on genetically modified (GM) food (Hwang et al. 2006), econometric analysis on the brand effect (Caves and Greene

[1] In addition, Japanese people are nervous about food because of many scandals such as Akafuku, Shiroi Koibito, Unagi (eel), Senba Kitcho, gyoza poisonings, Hida Gyu and so on.

1996), and investigation on the effect of price on subjective quality (Esposto 1988). Hwang et al. (2006) investigate the role of price as a signal for the quality of GM foods. They consider GM foods to be horizontally differentiated; some consumers prefer GM foods because of their nutritional content, and the others do not because of their questionable food safety. Through a conjoint analysis, it is shown that high prices as well as low prices act as a cue to the quality of products.

Caves and Greene (1996) consider a relationship between product quality and price. They examine 200 consumer goods and demonstrate that the price–quality correlation increases with an increase in the scope for vertical differentiation and declines for the innovative and "convenience" goods categories. Esposto (1998) focuses on the cigar industry and shows that price has a signaling effect of the quality of cigar.

While these papers suggest the existence of a signaling effect of the price of goods, the extent of this effect for food products, in particular, is unknown. Our study empirically investigates the seriousness of the signaling effect for food products, and considers its implications for waste policy.

2. Data

In February 2008, we conducted an online survey. The subjects were 912 females residing in Tokyo and the Osaka metropolitan area. The socio-demographic characteristics are summarized in Table 1. An example of the questions in the survey is as follows:

> Please imagine that there are three packages of eggs and you are going to buy one of them. Each of the products has a different price and different number of days remaining before the sell-by date. Let us assume that the characteristics of the eggs are the same irrespective of the different prices and days left before the sell-by dates. Which package would you want to buy?

Table 1: Socio-demographic characteristics

Variable	Mean (S.E.)	Universe mean
INCOME (ten thousand yen)	749.852 (5.375)	633.638
AGE	43.913 (0.147)	44.217

Table 2 presents an example of the choice sets. The evaluated attributes of the eggs are "price" and the "remaining days until sell-by date." Taking four levels for the above two attributes, we create 16 profiles by considering all the combinations; by randomly assigning two of these profiles we obtain 8 choice sets per respondent. Tables 3, 4, and 5 display the attributes and levels used in the choice set.

Table 2: An example of choice sets (egg)

Egg	A	B	C
Remaining days before the sell-by date (days)	10	3	14
Price (yen)	150	100	200

Table 3: Attributes and levels (egg)

Variable	Definition	Details
PRICE	Price	50, 100, 150 , 175 or 200 yen
DATE	Remaining days before the sell-by date	1, 3, 7 or 14 days

Table 4: Attributes and levels (noodle)

Variable	Definition	Details
PRICE	Price	25, 50, 70, 90, or 100 yen
DATE	Remaining days before the sell-by date	1, 3, 6, 9, or 12 months

Table 5: Attributes and levels (cookie)

Variable	Definition	Details
PRICE	Price	50, 100, 150, 175 or 200 yen
DATE	Remaining days before the sell-by date	0.5, 1.5, 2, 3, or 4.5 months

3. Model

We assume a random utility model for the analysis. When subject *n* chooses profile *i*, the subject's utility is given by

$$U_{ni} = V_{ni} + \varepsilon_{ni},$$

where V_{ni} is the observable component of U_{ni} and ε_{ni} is the unobservable component of U_{ni}. We denote the set of profiles that subject *n* can select on the basis of $C = \{1,2,\ldots J\}$. The probability that subject *n* chooses profile $i \in C$ is P_{ni}. When subject *n* chooses profile *i*, $U_{ni} > U_{nj}, (i \neq j)$ must be satisfied. Then, we obtain

$$\begin{aligned} P_{ni} &= \Pr[U_{ni} > U_{nj}, \forall j \in C, j \neq i] \\ &= \Pr[V_{ni} - V_{nj} > \varepsilon_{nj} - \varepsilon_{ni}, \forall j \in C, j \neq i]. \end{aligned}$$

Following McFadden (1974), we assume that ε_{ni} and ε_{nj} are independent with a univariate type I extreme value distribution. Then, the probability that subject *n* chooses profile *i* is

$$P_{ni} = \frac{e^{\mu V_{ni}}}{\sum_{j \in C} e^{\mu V_{nj}}},$$

where μ is a scale parameter. In this paper, μ is normalized to 1. This model is known as a conditional logit model. For food *k* (eggs, noodles, and cookies), the subject's choice depends on the price of the product, $PRICE_i^k$, and the number of remaining days until sell-by date, $DATE_i^k$. Then, the above equation can be rewritten as

$$P_{ni} = \frac{\exp(\beta_d^k DATE_i^k + \beta_p^k PRICE_i^k)}{\sum_{j \in C} \exp(\beta_d^k DATE_j^k + \beta_p^k PRICE_j^k)},$$

where β_d^k and β_p^k are parameters. Hence, we obtain the log likelihood function

$$\ln L = \sum_{n=1}^{N} \sum_{i \in C} \delta_n^i \ln P_{ni},$$

where N is the number of subjects, and δ_n^i is the dummy variable such that $\delta_n^i = 1$, if subject n chooses profile *I*, and 0 otherwise. By maximizing the log likelihood function, we estimate parameters β_d^k and β_p^k.

4. Methods

4.1 Empirical model

Every choice set in the case of eggs has an alternative item that has 14 days until sell-by date and is priced at 200 yen[2]. This alternative is characterized by the longest period until the sell-by date and the highest price. Similarly, for noodles and cookies, every choice set has one alternative item that has the longest period until the sell-by date and the highest price: 4.5 months and 200 yen, respectively, for cookies, and 12 months and 100 yen respectively for noodles.

We employ two types of models in our analysis. One includes the square term in the explanatory variables and the other does not. The reason for including the square term in the models is to enable us to investigate if there is a peak or a bottom in the consumers' utility for price and remaining days until sell-by date for each of the foods. If the utility has a peak or

[2] 1 yen is approximately equal to 1.1 cents as of February 2009

a bottom, an increase in the price raises the utility at some price level. Hence, we consider this result to arise from the perception that high price suggests high quality. That is, when the price is high, the consumer may perceive the food to be safe. Thus, consumers may even be pleased with price increases.

4.2 Model

We first consider Model 1. We estimate the utility functions for each of the foods: eggs, noodles, and cookies. The estimated function of the simple model is given as follows:

$$V_i = \beta_1^k \times PRICE_i^k + \beta_2^k \times DATE_i^k \times CONSCIOUS^k$$
$$+ \beta_3^k \times INCOME \times PRICE_i^k + \beta_4^k \times AGE \times PRICE_i^k + \theta \times ASC_i, \qquad (1)$$

where V_i is an observable part of the random utility function, which in this case, is assumed to be linear (*i* = *A*, *B*, *C*). β_j is the parameter to be estimated $(j = 1,2)$. $DATE_i^k$ and $PRICE_i^k$ are independent variables ($k = egg, noodle, cookie$). Let $DATE_i^k$ be the days remaining before the sell-by date for food k . The definitions of $PRICE_i^k$ and $DATE_i^k$ are given in Tables 2, 3, and 4. $CONSCIOUS^k$ is a dummy variable equal to 1 if the respondents care about the remaining days until sell-by date when they purchase food products and 0 otherwise.

To exclude the respondents who do not care about the remaining days, we indicate the interaction term of $DATE_i^k$ and $CONSCIOUS^k$. $INCOME$ and AGE are independent variables. $\beta_3^k \times INCOME \times PRICE_i^k$ and $\beta_4^k \times AGE \times PRICE_i^k$ are crossing terms. ASC_i is the constant term. θ is the parameter of the constant term.

The results of estimation are shown in Table 6. The effect of the price of eggs ($PRICE_i^{egg}$) on the subject's utility (V_i) is not statistically significant. The effect of the cross terms between the price of eggs ($PRICE_i^{egg}$) and the age of subject (AGE) is also statistically insignificant. Thus, this model has no explanation of the effect of price. Since we want to focus on the effects of price and sell-by date, we do not use the model with socio-demographic characteristics. In the following discussion, we exclude the terms of subject's income and age from an estimated equation.

Model 2 can be expressed as follows:

$$V_i = \beta_1^k \times PRICE_i^k + \beta_2^k \times DATE_i^k \times CONSCIOUS^k + \theta \times ASC_i \qquad (2)$$

It is the same as Model 1, except that crossing terms of socio-demographic characteristics are not contained in the model.

Model 3 can be expressed as follows:

$$V_i = \gamma_1^k \times PRICE_i^k + \gamma_2^k \times DATE_i^k \times CONSCIOUS^k + \gamma_3^k \times \left(PRICE_i^k\right)^2 + \theta \times ASC_i. \qquad (3)$$

Model 3 is the same as Model 2, except that the square term of price, $\left(PRICE_i^k\right)^2$, is contained in Model 3.

5. Results

Tables 6 and 7 show the results of Models 2 and 3, respectively. We now discuss the estimated results with respect to Model 2 (see Table 6). For all the three foods, the sign of β_1^k is negative and that of β_2^k is positive. This result shows that the subjects prefer a lower price and a longer remaining period until the sell-by date. The result seems to show that the subject's utility does not increase when the price rises. However, the results of Model 3 (see Table 7 and Figure 1) do not clearly indicate that the subjects prefer a lower price because there is a U-shaped utility function (with the lowest price at about 140 yen, and it is in the range of the suggested prices for eggs [50, 200].

Table 6: Estimation results for model 1

Parameter	Variable	egg		noodle		cookie	
		Parameter	*t*-statistics	Parameter	*t*-statistics	Parameter	*t*-statistics
β_1^k	$PRICE_i^k$	0.001	0.643	−0.055	1.648*	−0.029	−18.962***
β_2^k	$DATE_i^k$	0.046	13.509***	0.008	−19.766***	0.052	5.325***
β_3^k	$INCOME$	0.000	3.239***	0.000	2.755***	0.000	3.024***
β_4^k	AGE	0.000	−0.372	0.000	5.107***	0.000	6.293***
θ	ASC	-0.176	-4.344***	0.373	6.243***	-0.055	-0.929

***) p<0.01, **) p<0.05, *) p<0.1

Table 7: Estimation results for model 2

Parameter	Variable	egg		noodle		cookie	
		Parameter	*t*-statistics	Parameter	*t*-statistics	Parameter	*t*-statistics
β_1^k	$PRICE_i^k$	−0.003	−5.545***	−0.039	−40.581***	−0.018	−38.952***
β_2^k	$DATE_i^k$	0.193	28.099***	0.043	5.440***	0.135	7.140***
θ	ASC	−0.979	−19.965***	0.317	5.209***	−0.098	−1.635

***) p<0.01, **) p<0.05, *) p<0.1

Table 8: Estimation results for model 3

Parameter	Variable	egg		noodle		cookie	
		Parameter	*t*-statistics	Parameter	*t*-statistics	Parameter	*t*-statistics
γ_1^k	$PRICE_i^k$	−0.012	−4.314***	−0.023	−4.511***	−0.020	−6.771***
γ_2^k	$DATE_i^k$	0.192	28.022***	0.045	5.682***	0.134	7.084***
γ_3^k	$\left(PRICE_i^k\right)^2$	0.000	3.369***	0.000	−3.089***	0.000	0.702
θ	ASC	−1.183	−15.147***	0.507	5.943***	−0.147	−1.634

***) p<0.01, **) p<0.05, *) p<0.1

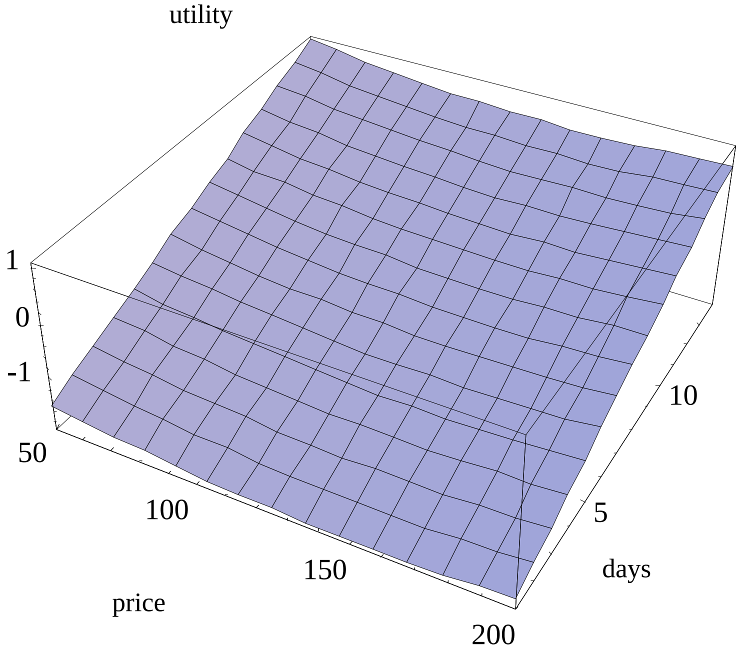

Figure 1: Utility function (egg)

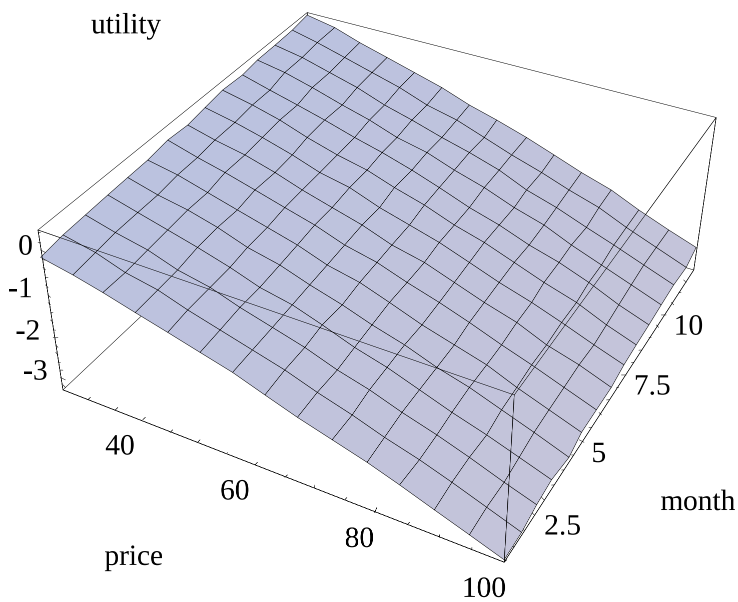

Figure 2: Utility function (noodle)

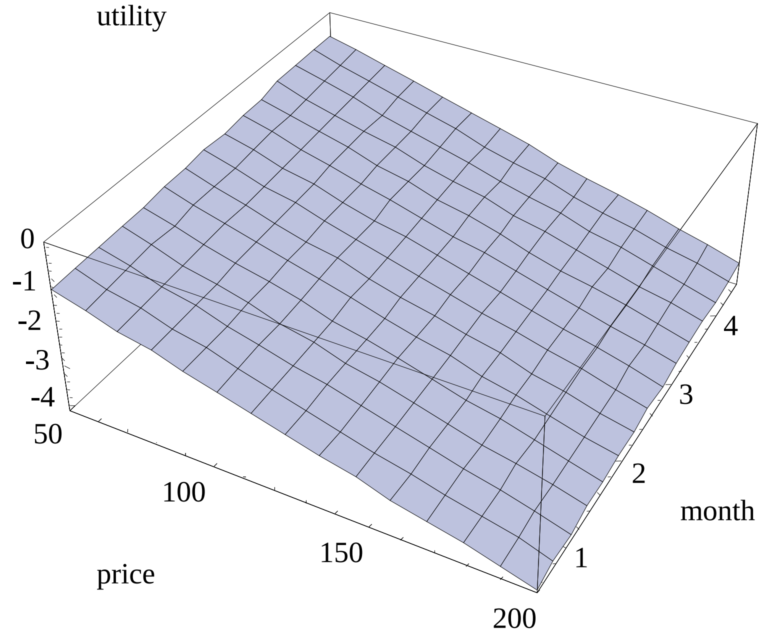

Figure 3: Utility function (cookie)

The reason for a bottom in the utility function can be explained as follows. An increase in the price has two effects. First, when the price rises, the consumer must reduce the amount of her/his consumption if the consumer must buy the food. Hence, the consumer's utility decreases. We call this the *price effect*. Second, when the consumer sees a highly priced food product, she/he may consider that item to be better in terms of quality or safety. Thus, the consumer gains a higher utility from the highly priced food item than that from a low-price. This is the *signaling effect*.

When the signaling effect is stronger than the price effect, an increase in the food's price was found to increase the subject's utility. Our result shows that if the prices of eggs were high enough, the signaling effect dominates the price effect. However, the signaling effects of noodles and cookies are dominated by the price effects. This may be attributed to the fact that the consumers pay more attention to the safety of perishable foods than that of nonperishable foods. Hence, the signaling effect from the price of eggs has a large effect on the consumers' utility, while those from the prices of noodles and cookies have an insignificant effect.

These situations are depicted in Figures 4 and 5. In these figures, the horizontal axis denotes the food's price, and the vertical axis the marginal utility from price change. The marginal utility from the signaling effect is positive and that from the price effect is negative. Thus, in Figure 4, if the egg's price is higher than 140 yen, the signaling effect dominates the price effect. That is, if the egg's price is higher than 140 yen, an increase in the price raises the subject's utility. On the other hand, in the case of noodles and cookies, the price effect always dominates the signaling effect. Hence, any increase in the prices of noodles and cookies reduces the subject's utility.

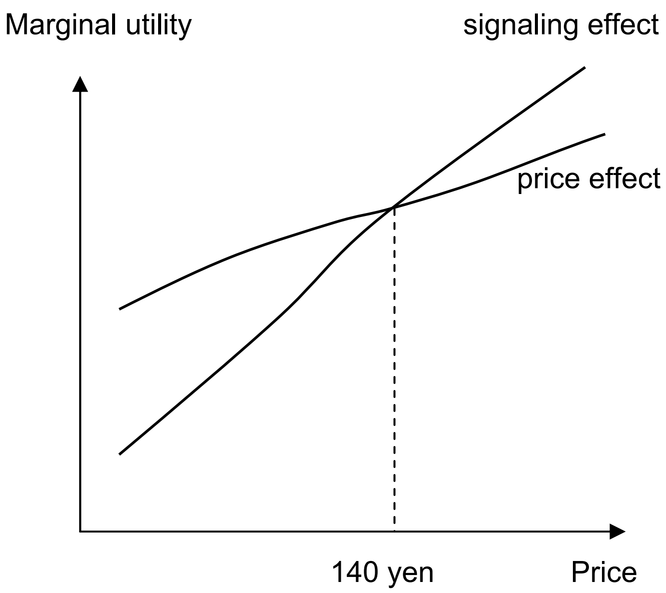

Figure 4: Marginal utility function (egg)

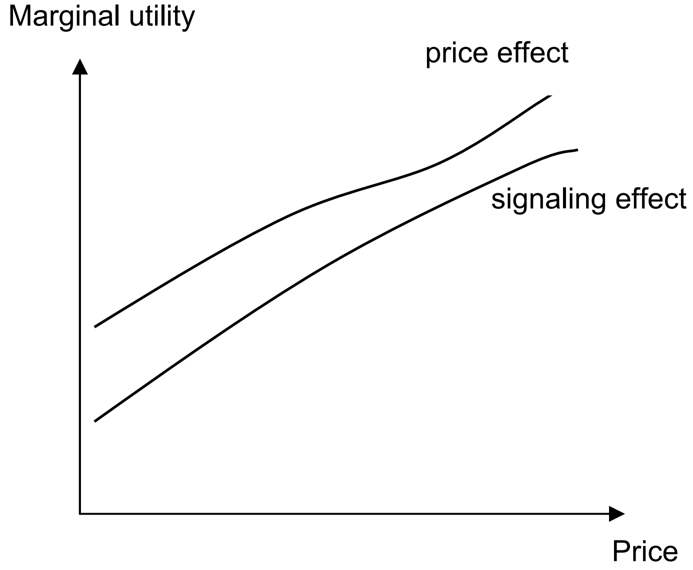

Figure 5: Marginal utility function (noodle, cookie)

6. Conclusion

Using the conjoint analysis, we investigated the signaling effect of price on consumers' utility. Different results are obtained in accordance with the nature of each food item. In the case of eggs – which have a short shelf-life – we found a significant signaling effect of price. When the price of eggs is high enough, a rise in the price increases the consumer's utility. In this case, the utility function assumes a U-shape. However, in the case of noodles and cookies, the signaling effect was not significant.

From the viewpoint of a waste policy, a discount in the price of eggs does not necessarily result in a reduction in the number of remaining packages for sale. This is because people make inferences about the quality from the price. On the other hand, in the case of noodles and cookies, the discounting of price is an effective tool for decreasing the wastage of foods.

The utility derived from noodles with 12 months remaining until the sell-by date with a price of 100 yen is equal to that of noodles with 6 months remaining until the sell-by date and with a price of 93 yen. Further, the utility from cookies with 4.5 months remaining until the sell-by date and with a price of 200 yen is equal to that from cookies with 2.25 months remaining until the sell-by date and with a price of 183 yen. If consumers gain a 10 percent discount, they buy noodles and cookies with half the period remaining until the sell-by date.

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